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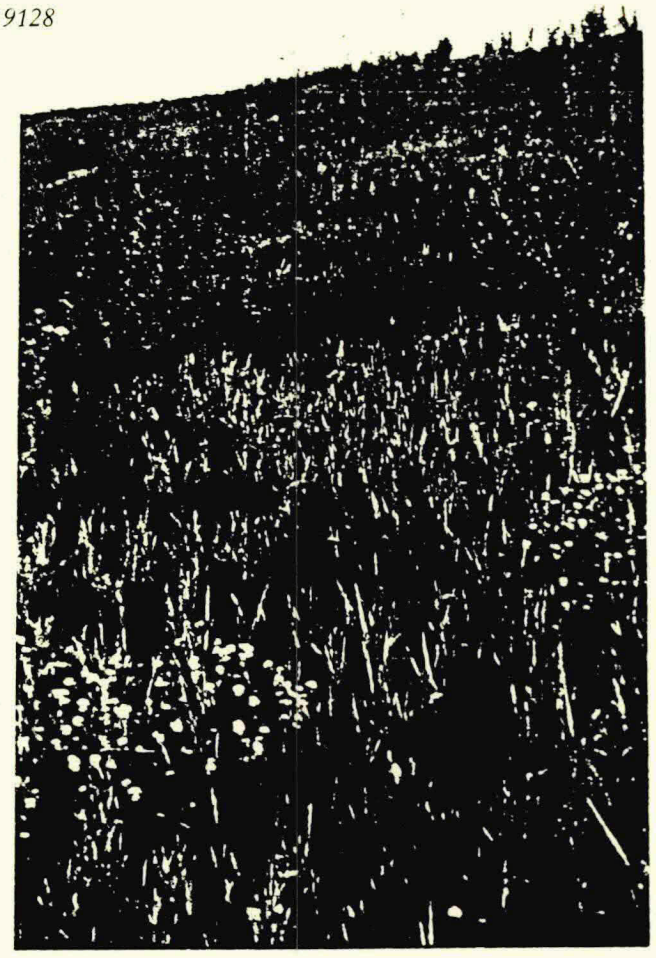

COVER VEGETATION PROGRAM

Fresh Kills Landfill, Staten Island NY

Submitted as section 3.4 of the NYSDEC Consent Order requirement report
Appendix A3: Draft Final Cover Design

February 1991

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Appendix A3: Draft Final Cover Report

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3.4 COVER VEGETATION PROGRAM

3.4.1 Rationale and Design Criteria

The establishment and maintenance of effective cover vegetation is a critical component of the successful closure of a landfill. The primary objective of the cover vegetation is to protect the integrity of the landfill final cover system. However, the landscape also influences end-use opportunities, scenic character, and habitat value of the site.

This section summarizes the Cover Vegetation Program for the Fresh Kills Landfill, including the rationale for the program, existing and proposed vegetative installations, methods of implementation, and monitoring procedures. The program includes a sequence of existing and continuing field trials designed to provide more detailed information on the establishment of the landfill final cover, providing a basis to facilitate refinement of existing techniques and strategies.

The most commonly used final cover type for landfills is a hydroseeded mix of non-native cool-season grasses. This is the least expensive conventional vegetative installation method that meets regulatory standards for vegetative cover as required for New York State municipal landfills:

> "A vegetative cover must be established and maintained on all exposed final cover material within four months after placement. If this cannot be achieved due to seasonal constraints, measures must be taken to ensure the integrity of the final cover system before the establishment of vegetative cover" [6NYCRR, Part 360-2.15(i)(6)].

The continued viability of this standard vegetative cover, however, would require a consistently applied and costly maintenance program at Fresh Kills, and might require irrigation at higher elevations and on steeper slopes (Gilman et al, 1983, 1985).

Beyond the preliminary goal of satisfying regulatory requirements, DOS is committed to meeting important goals related to future scenic and habitat

values. These goals have been raised by the surrounding community, civic groups, and governmental agencies, and are not perceived to be satisfactorily met by the standard convention of uniform cool-season grass cover. (Key Informant Survey, SCS Engineers, 1990).

Three years ago, under guidance from the Soil Conservation Service, Rutgers and Cornell University Co-operative Extensions, the NYCDPR Greenbelt, and various erosion control and vegetation specialists consultants, DOS became more involved in monitoring the performance of a wide variety of vegetative covers at Fresh Kills and began to explore the cause of vegetative decline in some areas. In 1989, DOS initiated the investigation of low-maintenance native plant communities for Landfill cover, including scrub/shrub woodland habitat types.

During the site investigations and conceptual design phases to develop end-use and closure plans for the Fresh Kills Landfill, a Cover Vegetation Program was established to meet and exceed the regulatory requirements:

- To develop the most cost-effective strategies for establishing and managing cover vegetation at the Fresh Kills Landfill that protects the integrity of the cap in accordance with 6 NYCRR, Part 360.

- Beyond the need for effective cover, to establish permanent native plant communities and associated habitats in compliance with the goals of NYCDOS, NYCDPR and the community around the landfill.

In contrast to a conventional cover plan which typically provides only one or a few proposed seed mixes and a single installation technique, the Cover Vegetation Program affords a wide variety of seed mixes, planting options, and installation and management techniques. These are geared to establishing a wide diversity of future cover types with a primary emphasis on native plant communities appropriate to the varied site conditions encountered at Fresh Kills. Because some of these strategies are adaptations from non-landfill sites the program is evolving to allow for refinement of techniques. This approach ensures innovation and flexibility as well as

appropriate assessment of the costs and effectiveness of new techniques and mixes.

During 1989 and 1990, for example, over 80 acres were planted using a variety of seed mixes and methods. Installation methods have included hydroseeding, dormant seeding, imprinting, the use of a modified seed drill and planting of propagated native grass plugs. Over 3000 woody plants have been established on and off the landfill cap.

The Fresh Kills Cover Vegetation Program is developing into one of the largest native habitat restoration projects in the Northeast; combined with proposed wetlands mitigation, this project will address a very wide array of environments, including steep slopes, swales, woodlands, grasslands, as well as salt and freshwater wetlands.

The following criteria are being used in the evaluation of cover types, installation and establishment techniques, and management procedures for the Fresh Kills Landfill:

- Low maintenance: Cover types should ideally require less maintenance over time as stable natural communities become established;

- Cost effectiveness: Cost assessments should address both short term (establishment) and long term (maintenance and management) needs;

- Constructibility: Planting techniques and management procedures suited to large-scale application and simple adaptations of existing technologies and equipment are required;

- Scenic value: An aesthetically satisfying cover type will be more cost-effective by reducing the need for screening, buffer planting, and fencing;

- Habitat value: Habitat quality is of value not only to DOS but also to NYCDPR, the likely recipient of the site after closure. Because of its size and location on the Atlantic Flyway and its juxtaposition to the Greenbelt, the Fresh Kills site has significant habitat potential in an otherwise highly developed urban corridor.

- Diversity: A variety of cover types are strongly recommended to avoid the problems of a monoculture, favor overall site diversity, and provide flexibility in response to seasonal constraints, unforeseen conditions, and new information.

The Cover Vegetation Management Program addresses five major areas:

Final Cover Soil (Section 3.4.2).
Stabilization and Establishment Techniques (Section 3.4.3).
Grassland Cover Types (Section 3.4.4).
Woodland Cover types (Section 3.4.5).
Monitoring and Maintenance (Section 3.4.6).

Each section presents an overview of the topic area and its role in the successful establishment of cover vegetation. This discussion is followed by a presentation of field trials already installed at the Landfill, and their role in determining the current program for planting the Landfill as well as future field trials requiring investigation.

3.4.2 FINAL COVER SOIL

3.4.2.1 Overview

Final cover soil affects many aspects of cover vegetation, including available moisture, drainage, soil fertility, pH, and the extent of available root zone. The growing medium for landfill vegetative cover is comprised of a layer of topsoil over relatively permeable subsoil, called the barrier protection layer. Together, these comprise the final cover soil and overlay the hydraulic barrier layer.

Under current 6 NYCRR Part 360 regulations, the minimum depth of the barrier protection layer is 24 inches which, in combination with 6 inches of topsoil, provides a total growing medium depth of 30 inches. The final cover soil specifications are the same for all proposed cap systems at this time. (See Section 3.1.3.3). Beneath the final cover soil, the cap systems includes a drainage layer over a hydraulic barrier layer and a gas venting layer.

Each layer impacts final cover vegetation and is potentially impacted by the vegetation. One objective of the Cover Vegetation Program is to ameliorate the growing conditions for vegetation to the extent feasible while protecting the integrity of the capping system.

- Gas Venting Layer: High levels of LFG present in the soil horizon indirectly reduce the vigor of vegetation and may even cause dieback mortality (Flower, et al, 1981, 1978; Duell et al, 1986; Leone & Flower, 1982). However, at Fresh Kills, the gas venting layer will work in combination with the hydraulic barrier layer to reduce migration of LFG into the cover soil horizons. For this reason, LFG impacts on vegetation are expected to be minimal. The health of cover vegetation will prove an excellent tool for detecting gas leakage.

- Hydraulic Barrier Layer: The hydraulic barrier layer will be comprised of either an impermeable soil layer or a geomembrane. Woody plants have generally not been recommended for use over soil hydraulic

barriers because of concern that the integrity of the barrier might be compromised by root growth (Robinson et al 1990). In order to address this issue comprehensively, a sequence of Root Penetration Test Plots have been installed to evaluate possible impacts of proposed vegetation, both woody and herbaceous. According to recent studies, root penetration does not appear to be a problem on a geomembrane. "This latter problem does not apply to landfills sealed with synthetic polymer sheets (USEPA 1980[b]; Lutton 1982), which are impervious to root penetration" (R.E. Landreth, pers. comm) (Robinson, et al 1990)".

- Drainage Layer: The drainage layer is intended to control saturation of the barrier protection soil. The addition of this layer may create more droughty conditions on the Landfill with potential consequences for cover vegetation. Drought-tolerant native plant communities are being evaluated on site, as are installation and management methods to better retain moisture in the topsoil layer. The use of irrigation may need to be investigated if the drainage layer impacts on cover vegetation are significant.

- Barrier Protection Layer: The design of the barrier protection layer is determined primarily by its regulatory specification:

  "A barrier protection layer of soil..... must be adequate to protect the soil barrier layer from desiccation, cracking, frost action and root penetration" 6NYCRR Part 360-2.13 (r)(2)(iii). For a geomembrane cover, the barrier protection layer "must be adequate to protect the geomembrane barrier layer from frost action and root penetration" 6NYCRR Part 360-2.13 (q)(2)(iii).

For the purposes of the Draft Final Cover Plan, DOS assumed no change in the existing subsoil specification, which has been determined primarily by the engineering requirements for site drainage. Due to the permeability requirements of this layer (10^{-3} cm/sec), sandy soils with low pH and fertility are typically used, which is primarily responsible for the poor quality of the growing medium for the plants at the Landfill. This layer functions as the

moisture reservoir for the vegetation. A greater subsoil depth would increase the moisture reservoir (Insley and Carnell 1982; Gilman et al 1985, 1983). The appropriate depth of this layer is currently being evaluated. Because this standard has been revised over time, depths varying from 12-24 inches have been used on the Landfill. These areas, together with increased barrier protection layer depths are currently being assessed in field trials.

3.4.2.2 Field Trials & Current Program

- Topsoil Layer: Of the cover soil layers, the topsoil layer is the least constrained by engineering considerations and the most important to horticultural concerns. It therefore represents the most significant opportunity to ameliorate the adverse growing conditions at the Landfill. The current topsoil specification has been modified to reflect agricultural as well as engineering criteria. A testing program has also been implemented to ensure better conformance with the specifications. A variety of soil amendments have been assessed, including a water-holding polymer, liquid nitrogen, organic fertilizers, and varying amounts of organic matter.

The only amendment in these trials judged successful and cost-effective to date is the addition of increased amounts of organic matter trials led to the amendment of the topsoil specification to include a minimum of 5% organic matter for improved moisture retention and fertility enhancement in the upper soil layer. Beyond the 5% minimum organic matter specified for inclusion in the topsoil, additional compost (up to 50% by volume), is incorporated into the topsoil layer where possible. The addition of this organic matter to the topsoil is currently being coordinated with the city-wide yard-waste composting operation now situated at Fresh Kills, which provides a free source of compost and a consistent product. The use of organic matter may eliminate the need for chemical fertilizers. Peat Moss also has been eliminated as an option because of its high cost and the environmental impacts of peat excavation; peat is easily replaced by compost. No further revisions or evaluations of the topsoil specifications are currently proposed. The current topsoil specification is included in Appendix A for review.

- Depth of Final Cover Soil: The total depth of 30" growing medium is deemed adequate for grassland establishment. However, at least 36" is generally recommended for supporting tree growth (Gilman et al 1985, 1983). This additional soil depth is geared to more conventional use of specimen trees and is not necessarily required to support the native scrub woodland communities proposed for use at the landfill. If additional cover soil is used, however, costs may be offset by the benefits associated with an increase in soil dept, including a reduced need for irrigation and better vegetative stabilization. Two existing sites have been prepared where soil depths exceed 30 inches, one of which has been sown to cool-season grasses and the other to warm-season grasses. Both of these are scheduled for woody planting in the Root Penetration Test Plot program.

- Assessment of Vegetation Impacts Associated with the Use of Soil Hydraulic Barrier Layers: Some mineralogy problems associated with clay sources from the region have been documented (Belcher et al 1981; New Jersey Department of Environmental Protection, 1984). If clay is selected for use as the soil hydraulic barrier layer at Fresh Kills, a mineralogical study of each clay source will be completed. Several alternatives to clay are also being considered for use as the soil hydraulic barrier layer, including hydrated sludge and higher permeability soils on steep slopes. If further investigation of the use of soil hydraulic barriers is pursued, field trials will be implemented to evaluate impacts, including root penetration and monitoring of changing soil conditions.

- Increased Use of Recycled Materials and Composite Soils: Significant long-term cover soil concerns regarding soils are cost, availability and quality. High quality topsoil is becoming less available and all soil costs have and will continue to increase. It is likely that, over time, cover soils will increasingly become a composite-made product, utilizing a array of recycled and waste products which might otherwise be

disposed of at the Landfill. As noted above, no major modifications to the new topsoil specification are currently proposed, but future changes will be considered as new materials become available. Possible considerations include crushed construction rubble and dredge spoils. A small area of dredged materials is currently being treated with two probiotic soil amendments to evaluate their effectiveness in creating a reusable soil from dredge spoils.

3.4.3 STABILIZATION AND ESTABLISHMENT TECHNIQUES

3.4.3.1 Overview

The stabilization and establishment techniques used and proposed for final cover vegetation at the Landfill have two major functions:

- Providing erosion and sediment control prior to vegetative establishment to reduce initial soil loss.

- Establishing vegetation, primarily by seeding herbaceous species, but also by planting vegetative plugs, bare root, container, bulb plant materials and transplanting.

The development of more effective stabilization and establishment techniques has been a major focus of the field trials undertaken in the past three years. During this time, the hydroseeding specification has been modified and three other techniques have been developed and field tested to establish a vocabulary of methods appropriate for varying conditions, timing, and seed mixes. All these techniques have proven effective under specific conditions, and will continue to be utilized in final cover vegetation establishment.

Initial field trials have to address the following concerns:

- Improvement of erosion and sedimentation control by providing a less erodible soil surface and including mulch in all specifications.

- Improvement of soil seed contact, providing higher rates of germination and applicability for a wider variety of species and mixes.

3.4.3.2 Field Trials and Current Program

The following stabilization and establishment techniques have been field tested, and have proven effective for vegetation establishment. The recent field trials and the continuing uses of each of these techniques are described below:

- Land-imprinting: This technique mini-terraces the soil surface to give better erosion control and moisture retention. The imprinter provides a one-step process for land texturing and seeding using a towed modified roller and seed box. Seed is delivered from a calibrated seed box and immediately pressed into the soil by a roller (Dixon 1988). This technique can be used with a variety of seed mixes with considerable success. The mixing of oat bran with grass seed in the seed box ensures even application and controls the fluffy warm-season grass seed.

- Broadcast and Track: The tracking equipment provides better germination through improved soil/seed contact. It has been used successfully on site with warm-season grasses. When hay mulch and/or a nurse crop is added, this method provides excellent erosion control.

- Drill Seeding: Drill seeding is a method for directly embedding seed in the soil to achieve better germination. Several field trials of both cool- and warm-season grasses have been installed via drill-seeding, and have proven particularly effective for establishment of warm-season grasses. Warm-season grasses generally have fluffy seeds which are not easily hydroseeded. This therefore increases the value of the drill-seeding technique. The cost-effectiveness and applicability of this technique on 2.5H:1V slopes needs to be further investigated.

- Two-Step Hydroseeding: A modified hydroseed and hydromulch specification has been developed to include a two-step installation. The seed is hydraulically applied and tracked over with a dozer before the

mulch is applied. This improves soil-seed contact. Due to the success of this technique, one-step hydroseeding has been eliminated for use at the Landfill. If high winds preclude the use of hydroseeding, any of the three installation techniques mentioned above can be used instead.

- Mulch: Mulch provides erosion control during the establishment period and fosters seed germination and seedling survival. At this time, the use of a punched straw mulch has proven most cost-effective. For hydromulching, the use of paper fiber mulch has proven ineffective, and has been replaced by the use of wood fiber hydromulch at the Landfill.

At this time, most of the major field testing of techniques has been completed. However, a variety of techniques will continue to be assessed in order to better match techniques to seed mix type, seasonality, site conditions and to obtain more detailed information on costs. In the event that 2.5H:1V slopes are approved for use at the Landfill, additional field-testing will be required.

- Slope Gradient and Length: All of the above field trials are being undertaken on existing landfill slopes, none of which exceed 3H:1V. The current grading proposed for Sections 1/9 and 6/7 calls for 2.5H:1V slopes between benches, which may require additional measures to ensure stability. At this time, DOS is taking a conservative approach and is proposing the use of tacked jute and long straw matting or other similar alternatives until such time as field trials can be completed to verify and refine actual requirements. Initial installations on steeper slopes will be monitored more frequently to evaluate the success of vegetative establishment. Further field trials may be necessary to evaluate the need for supplementary watering on the steeper slopes. Additional installation technique modifications will also be addressed, such as operating the imprinter with a winch on steep slopes and additional drill-seeding.

- Small scale trials for stabilization and vegetation establishment techniques on full-length 2.5H:1V slopes should be undertaken prior to large scale applications. Separate trials are recommended for the different hydraulic barrier layers which are selected.

- Erosion assessment using precipitation simulation is strongly recommended to evaluate the effectiveness of methods and magnitude of costs.

- Equipment modifications for stabilization, establishment and maintenance should be assessed because most conventional equipment is not suited for use on slopes exceeding 3H:1V.

3.4.4 GRASSLAND COVER TYPES

3.4.4.1 Overview

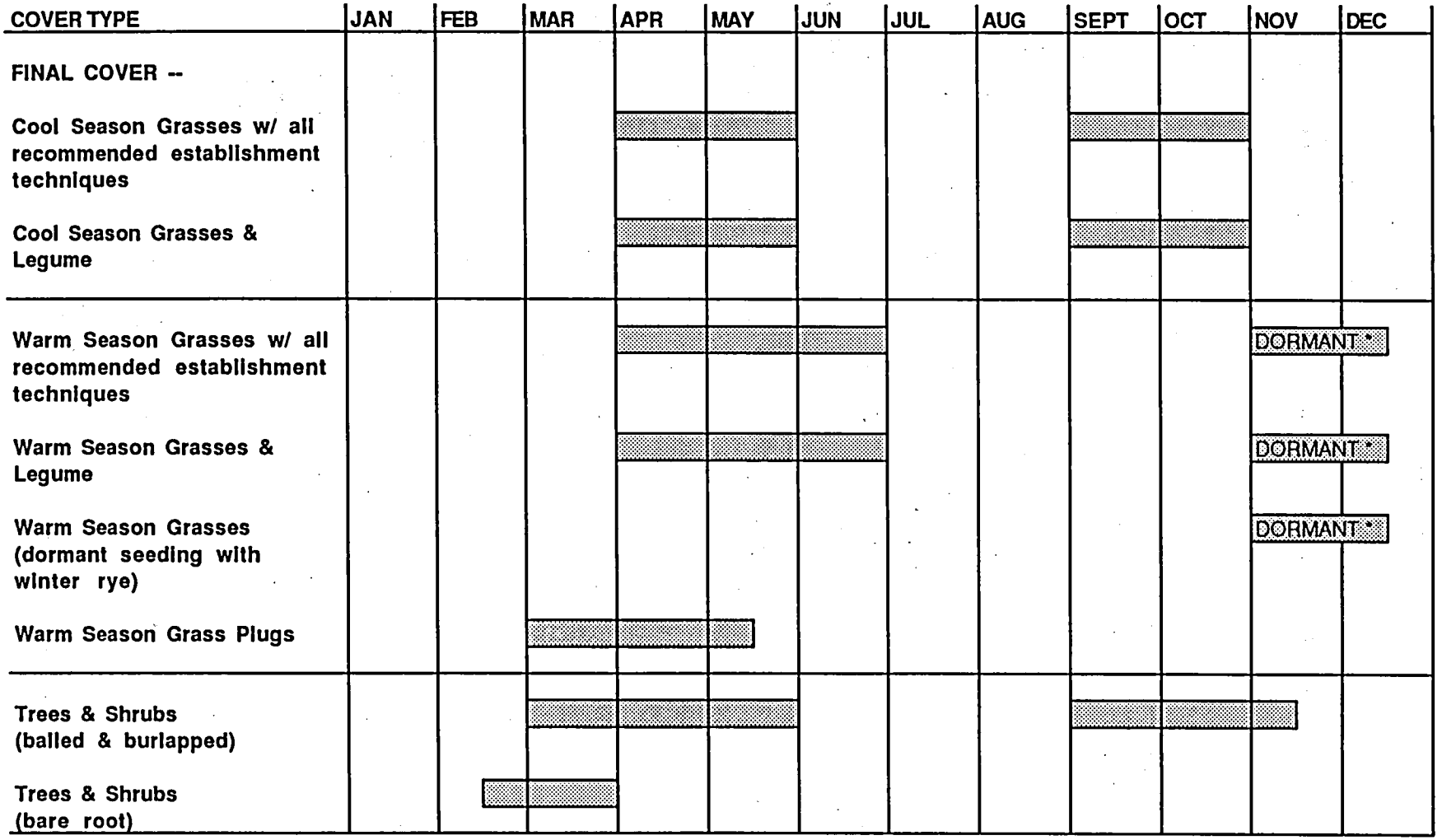
Several mixtures developed for the field trials have proven effective in establishing stable grassland vegetative cover at the Landfill. The mixtures provide options designed to maximize planting seasons (see Exhibit 1) and address a variety of landfill conditions. This section presents the general benefits and limitations of the grassland cover types, and rationale for species mix selection.

There are two major types of grasslands which occur in the Staten Island region; cool-season and warm-season. Because of the advantages cited in section 3.4.1., Design Criteria, cool-season grasses have been the traditional vegetation method for stabilizing landfills in the northeast. To date at Fresh Kills, cool-season grasses have been established on approximately 45% of the 120 acres of final cover slopes.

The primary growth seasons for cool-season grasses are spring and fall; the plants are dormant in the summer and winter. Many species of cool-season grasses establish quickly after seeding, and can be sown in the spring or fall to provide good initial erosion control, which is especially useful on slopes There are, however, drawbacks to their use. Many cool-season grass species do not tolerate heat well, and may die back under hot summer conditions. As elevations increase at the Landfill, the use of irrigation may be required to sustain cool-season grass cover.

Cool-season grasses are primarily introduced plants, and therefore do not fulfill the DOS desire to reestablish native vegetation on the Landfill. In addition, complete reseeding of cool-season grass areas has frequently been required because follow-up maintenance was not performed. Maintenance requirements are high for cool-season grasses; they tend to require regular fertilizing, liming, chemical treatment, and mowing (Godfrey and Dickerson, 1988). Although the establishment cost for cool-season grass is low, long-term costs have already proven high and are expected to remain so.

Exhibit 1 - Calander for Seeding Grasslands



* Dormant only - under evaluation

Warm-season grasses grow during the warmer, summer months and their on-going maintenance needs are much lower than the non-native cool-season varieties. Warm-season grasses have both advantages and disadvantages relative to the more commonly used cool-season grasses. The advantages are drought tolerance, lower maintenance needs, better habitat value, tolerance of lower pH soils, and once established, better soil conservation. The disadvantages are slow germination (hence a longer period of greater risk of soil loss), more costly installation, greater fire susceptibility, and greater limitations in the period of sowing (April-June). The erosion caused by slow establishment can be mitigated by addition of a nurse crop, which germinates quickly but will eventually dieback in favor of the warm-season grasses. The use of warm-season native grasses is neither encouraged nor precluded by DEC, but has not yet been adopted for widespread use at landfills. The USDA Soil Conservation Service has had documented success with warm-season grass establishment on reclaimed gravel pits and abandoned mine sites (Godfrey and Dickerson, 1988). The direct establishment of warm-season grasses at Fresh Kills has met with considerable success and none of the trial sites has required overseeding to date. Given the habitat value of reduced maintenance need, DOS is proposing to establish warm-season grasslands to the extent feasible consistent with seasonal requirements.

A summary of the relative attributes of cool versus warm-season grasses are given in Exhibit 2.

3.4.4.2 Field Trials and Current Program

A wide variety of grasslands have been installed at the Landfill using different combinations of establishment techniques and seed mixes. All field trials have been conducted on 3H:IV slopes or shallower at this time. Exhibits 3 and 4 describe the existing installations, details of the mix and installation method used, as well as the level of establishment through the fall of 1990.

The existing cool-season installations have included the use of imprinting, drill-seeding, broadcast and track techniques, and hydroseeding. Preliminary results indicate minimal vegetative establishment differences between the various installation techniques. All techniques are therefore applicable for

RELATIVE ATTRIBUTES OF COOL- & WARM-SEASON GRASSES		
WARM-SEASON	ATTRIBUTE	COOL-SEASON
SLOWER	GERMINATION	FASTER
HIGHER*	INSTALLATION COST	LOWER*
NONE	RECOMMENDED LIMING	1 x PER YEAR
NONE**	RECOMMENDED FERTILIZING	1 x PER YEAR
ONCE EVERY 3 YRS	RECOMMENDED MOWING	1-4 x PER YEAR
LOWER*	30-YR REGULATORY MAINTENANCE COST	HIGHER*
GOOD	LOW PH TOLERANCE	POOR
EXCELLENT	HABITAT VALUE	LIMITED
GOOD	SCENIC VALUE	LIMITED
MODIFIED	INSTALLATION	STANDARD
EXCELLENT	LONG-TERM STABILITY	POOR IF UNMAINTAINED
POOR***	SHORT-TERM EROSION CONTROL	GOOD
GOOD	LONG-TERM EROSION CONTROL	BAD IF NOT MAINTAINED
LOW	WATER REQUIREMENTS	HIGH
NOT GOOD	FIRE BREAK	GOOD IF MOWN
NARROWER	SEEDING WINDOW	BROADER
* As per Andropogon Associates cost-estimate, 1990.		
** After first year		
*** If not sown with a cool-season nurse crop		

Exhibit 2

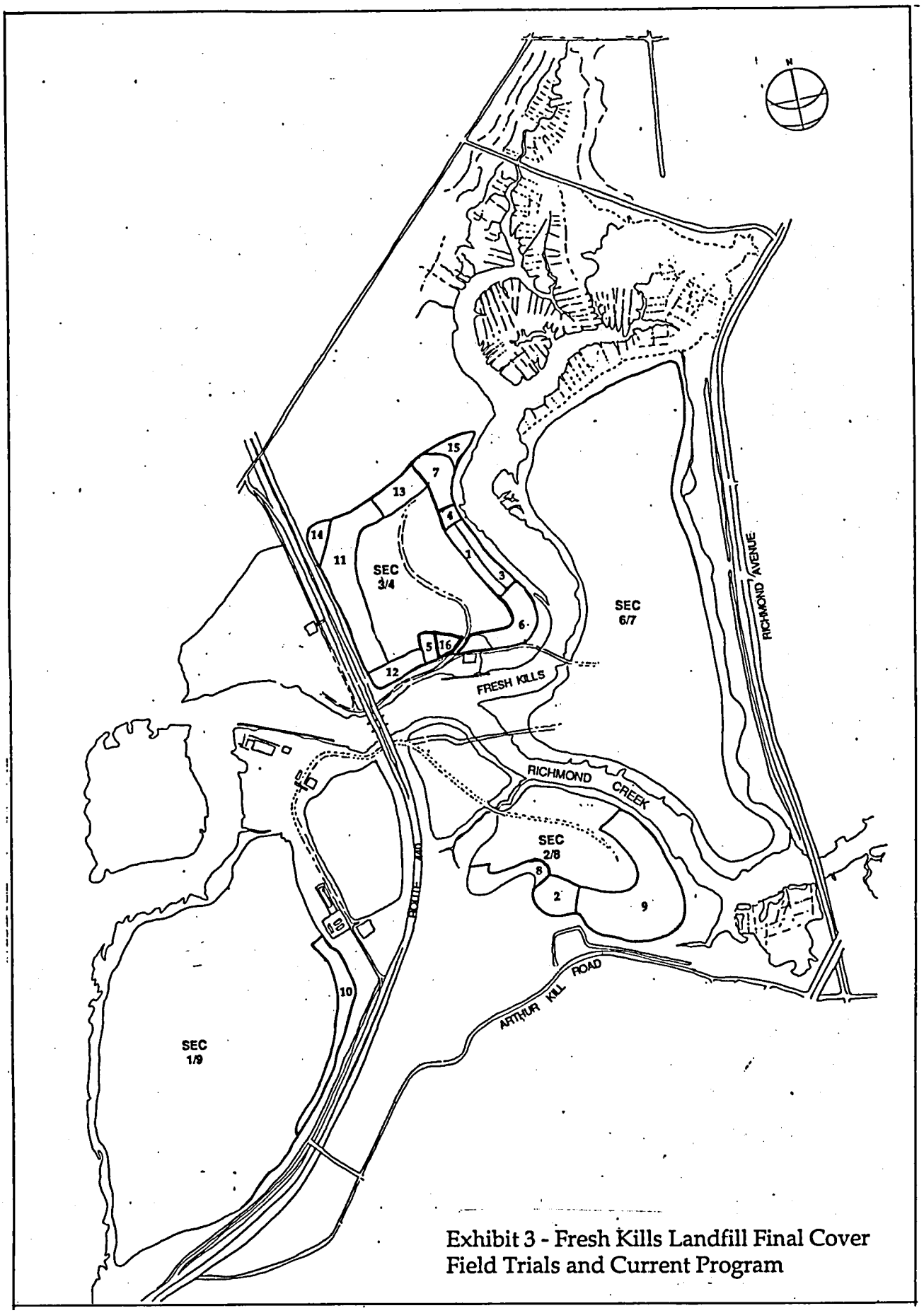


Exhibit 3 - Fresh Kills Landfill Final Cover Field Trials and Current Program

Exhibit 4 - Field Trials and Current Program

SITE LOCATION	INSTALLATION PURPOSE	VEGETATION TYPE	ENVIRO FACTORS	DATE	INSTALL METHOD	REMARKS	RESULTS Spring '90	RESULTS Fall '90
1	Drop-seeding of	WARM SEASON	Aspect-E	Jun-89	Broadcast &	Seeding on poor soil	50-60% coverage	No visible erosion
SEC 3/4	warm-season grass	GRASSES			Tracked	Heavy rates of seeding	Switchgrass dominant	-excellent cover &
4.5 acres		Standard DOS mix:						root development
		Little bluestem - "Aldous" or						
		"Camper" 6lbs/ac						
		Big bluestem "Niagara" 6lbs/ac						
		Switchgrass "Blackwell" 4lbs/ac						
		Indiangrass "Cheyenne" 4lbs/ac						
		Sand lovegrass "NE-27" or						
		"Bend" 2lbs/ac						
2	Dormant seeding of	WARM SEASON	Aspect-S/SW	Oct-89	Dormant Seeding	Good soil; composted leaf	80% coverage:	100% coverage. No warm-
SEC 2/8	warm-season grass	GRASS			Broadcast	mulch added to topsoil	Winter rye predominant	season grass germination.
		Standard DOS mix			& Tracked	1:4 rototilled		Winter rye die-off.
		with winter rye						Many volunteer fords
3	Dormant seeding of	WARM SEASON	Aspect -E	Nov-89	Dormant Seeding	Excellent soil;	50%-60% coverage, with	100% coverage. No warm-
Strip 1 of	warm-season grass	GRASS			Broadcast	composted leaf	bare spots	season grass germination.
Test Plots	Effect of selected	Standard DOS mix			& Tracked	mulch added to	Winter rye predominant	Winter rye die-off.
SEC 3/4	soil amendments	with winter rye				topsoil, 1:4 rototilled		Many volunteer fords
3	Cost-benefit of	WARM SEASON	Aspect-E	May-90	plugs -- 12" o.c.	Partially complete -		70% of insatllations
Strip 2 of	mechanical installation	GRASSES				All plugs installed by hand		established
Test Plots	for grass plugs. Effect	Andropogon scoparius				in May '90. Second half		Indiangrass upto 6' tall
SEC 3/4	of soil amendments	Switchgrass & Indiangrass				installed late summer 1990		
3	Cost-benefit of	WARM SEASON	Aspect-E	May-90	Drilled	Andropogon scoparius		Good germination
Strips 3 & 4	embedding warm-season	GRASSES			Modified native	only seeded. Cool-Season		80% coverage
of Test Plots	grass seed. Effect of	DOS mix			seed drill	nurse crop not seeded.		Fastest top growth of all
SEC 3/4	soil amendments	32lbs/ac						installations to date
1.6 acres								
4	Embedding seed and	WARM & COOL	Aspect-E	May-90	Drilled	Cool-Season nurse crop		Good germination
SEC 3/4	erosion control	SEASON GRASSES			Modified native	not seeded		80% coverage
		Andropogon scoparius (15lbs/ac)			seed drill			Fastest top growth of all
		with and without Sheep fescue						installations to date
5	Stabilization/Intercomp-	WARM SEASON	Aspect-S	May-90	Hydroseeded	Losses due to stormwater		Good germination - 85%
SEC 3/4	etetiveness of seed mix	GRASSES				erosion. Reseeded July'90		coverage - Cool-season
2 acres		Standard DOS mix				w/ cool-& warm mix - See 8		grasses predominant

Exhibit 4 - Field Trials and Current Program

SITE LOCATION	INSTALLATION PURPOSE	VEGETATION TYPE	ENVIRO FACTORS	DATE	INSTALL METHOD	REMARKS	RESULTS Spring '90	RESULTS Fall '90
6 &7	Stabilization/Intercomp-	WARM & COOL	Aspect-E	May-90	Hydroseed	Topsoil prepared by		Good germination
SEC 3/4	etetiveness of seed mix	SEASON GRASSES				amending w/compost &		85% coverage
		Standard DOS mix				discing entire slope		Clovers & Cool-season
		w/ fescue & 10% rye						grasses predominant
8	Stabilization/Intercomp-	WARM & COOL	Aspect-W/S	May-90	Hydroseeded			Good germination
SEC 2/8	etetiveness of seed mix	SEASON GRASSES						85% coverage
4.5 acres		Standard DOS mix						Cool-season grasses
		w/ fescue & 10% winter rye						predominant
9	Stabilization/Intercomp-	WARM & COOL	Aspect E/S	May-90	Broadcast &			Good germination
SEC 2/8	etetiveness of seed mix	SEASON GRASSES			Tracked			85% coverage
21 acres		50% standard DOS mix						Cool-season grasses
		50% rye						predominant
10	Seed mix, installation	WOODY SEEDING	Aspect NE/E	1986	Hydroseeded	Subject to many	Good coverage - 100%	Good coverage -90%
SEC 1/9	method & on-going	&				reseeding & over-seeding	No evidence of woody	No evidence of woody
40 acres	maintenance evaluation	COOL SEASON GRASSES				efforts	plants. Many volunteer	plants. Volunteer
		Cool-season grass/wildflowers				Fertilized twice, mown	forbs. Some legumes but	forbs have died back.
		Tall Fescue				once	fescues predominant	Some legumes but
		Kentucy Bluegrass						fescues predominant
		Perennial & Annual Rye						
		Native Tree & Shrub Mix						
11	Seed mix, installation	COOL SEASON	Aspect-W/SW	Oct-88	Hydroseeded	Poor topsoil - but	90% coverage	100% coverage
SEC 3/4	method & on-going	GRASSES			with hay mulch	amended with organic matter	Heavy legume cover:	The rest remains the same
19 acres	maintenance evaluation	Tall Fescue				Fertilized once w/ 10-20-20	clover, flat pea,	
		Perennial Rye				Mown three times	crown vetch etc.	
		Alsike Clover & Flat pea					60% fescue; 20% per. rye	
		Bushel of Annual Rye/acre					20% clover & flat pea	
12	Seed mix, installation	COOL SEASON	Aspect-S	Sep-89	Hydroseeded	Good soil: leaf mulch added	70% coverage	
SEC 3/4	method & on-going	GRASSES					85% fescue	
	maintenance evaluation	Latthca Flat pea & HS 25lbs/ac					90% perennial rye	
		Perennial Rye 30lbs/ac						
		Fescue						
13	Installation methods &	COOL SEASON	Aspect-N/W	Oct-89	Upper band:	Good soil: leaf mulch added	85% coverage	80% coverage
Test Plot	soil amendments	GRASS	WEST		Hydroseed/Track		Winter rye predominant	Winter rye die-off
SEC 3/4		TEST PLOTS I			Lower band:		40% basal area coverage	50% basal area coverage
					Brillion seeded		by fescues	by fescues
14	Germination & growth	NATIVE PLANT	Aspect-W	Oct-88	Hydroseeded,		The site still has bare	Warm-season grasses
SEC 3/4	of woody plant material	TEST PLOT			then hand sown		areas; poor soil & erosion	becoming established.
2.2 acres	and wildflowers	Oversown with					inearly stages	Myrica reseeding itself
		rhus, myrica, wildflowers,						
		switchgrass, & Indiangrass;						
		juniper virginiana						
		also plugs of switchgrass						

Exhibit 4 - Field Trials and Current Program

SITE LOCATION	INSTALLATION PURPOSE	VEGETATION TYPE	ENVIRO FACTORS	DATE	INSTALL METHOD	REMARKS	RESULTS Spring '90	RESULTS Fall '90
15	Woody plant material	ERICACEOUS						
SEC 3/4	on and off clay cap	Demonstration						
	to review:	Planting						
	1. Survival rates of species	Vaccinum angustifolium	Aspect-NE/E	Spring 1990	1-2-3 gallon			
	2. Stabilization benefits	Vaccinum corymbosum	"	"	"			
	3. Effect of roots on cap	Aronia arbutifolia	"	"	"			
	4. Plant recruitment and	Rhus glabra	"	"	"			
	seed dispersal.	Rhus copallina	"	"	"			
		Myrica pennsylvanica	"	"	"			
		Leiophyllum buxifolium	"	"	"			
		Kalmia angustifolia	"	Fall 89	"	Very cold weather during		
		Amelanchier canadensis	"	"	"	installation. Some plants		
		Amelanchier stolonifera	"	"	"	frozen		
		Lyonia mariana	"	"	"			
		TREES:	"	"	"			
		Quercus ilicifolia	"	Spring1990	1" caliper			
		Quercus phellos	"	"	2" to 2-1/4"			
		Quercus marilandica	"	"	1" caliper			
		Prunus maritima	"	"	"			
		Quercus stellata	"	"	"			
		Pinus rigida	"	Fall 89	"	Very cold weather during		
		Castanea pumila	"	"	"	installation. Heavy losses of		
		Pinus virginiana	"	"	5-6'	pines		
		Pinus echinata	"	"	5-6'			
		Arctostaphylos uva ursi	"	"	"			

Exhibit 4 - Proposed Field Trial Installations

SITE LOCATION	INSTALLATION PURPOSE	VEGETATION TYPE	ENVIRO FACTORS	DATE	INSTALL METHOD	REMARKS	RESULTS	RESULTS
?	Interaction of different plant material with geomembrane cap	ROOT PENETRATION TEST PLOTS		? Depends on seed window		Will be set up as per # 16 (over clay) as soon as a geomembrane is installed.		
16	Interaction of different plant material with clay cap	ROOT PENETRATION TEST PLOTS	Aspect - S	Spring '90		Warm- and cool season grasses seeded only so far. Woody's still to install.		
?	Installation techniques to improve erosion & stabilization on 2.5H:1V full-length landfill slopes	COOL SEASON GRASSES E & S FIELD TRIALS		? Depends on seeding windows	Land Imprinter 2-Step Hydroseed	Erosion & Stabilization Test Plots (combine w/ GeoServices simulated rain-fall test for geomembrane)		
?	Seed mixes and installation method refinements	COOL-SEASON GRASS FIELD TRIALS		? Depends on seeding windows	Land Imprinting 2-step Hydroseed Broadcast/Track Drill	See Exhibit Current Program Recommendations		
?	Seed mixes and installation method refinements	COOL- & WARM-SEASON GRASS FIELD TRIALS		? Depends on seeding windows	Land Imprinting 2-step Hydroseed Broadcast/Track Drill	See Exhibit Current Program Recommendations		

cool-season grass installation, the final selection depending on specific landfill slope conditions and cost factors.

The cool-season installations comprise some of the older areas of closed landfill. Despite a variety of original seed mixes, after a few years the vegetative cover is mainly dominated by species that have volunteered on site, and most of the original species are no longer present.

The existing warm-season grass installations are diverse: warm-season grass mixtures have been installed by drilling, broadcast and track, imprinting, and hydroseeding. Thus far, techniques which embed seed have proven most effective. Drill-seeding produces more rapid cover, but is the most costly. Both broadcast and track and imprinting techniques may ultimately prove more cost-effective.

A recent hydroseeding of a warm and cool-season mixture has been successful in the establishment of the cool-season grasses; continued review will indicate whether warm-season grasses will develop gradually from this mixture, or if they will be out-competed by the more aggressive cool-season species. Additionally, dormant seeding of warm-season grasses has been undertaken, but is not yet a reliable establishment method. Further refinement of this technique may still allow development of a late fall warm-season grass seeding option.

Existing warm-season grass installations include warm-season only mixtures, as well as mixes combining warm and cool-season species. The use of pure warm-season mixtures has proven problematic; up to two years is required to develop sufficient top growth to provide effective erosion control and stabilization. Therefore, mixtures that include a cool-season nurse crop or companion species are preferable at this time, although the successful development of native plant community will require close review over the next few years.

Species and techniques successfully evaluated in the field trials will continue to be utilized and refined for grassland establishment. As already stated, one goal of the Cover Vegetation Program is the establishment of landscape

diversity throughout the site. Establishment of just one seed mix over a large area will not meet this requirement and the use of a single mix is not recommended for closure of large-scale areas. Diversity will be maintained most cost-effectively by using a single installation method with several different seed mixes for large-scale final closure installations.

Exhibit 5 presents the seed mixes which are currently considered suitable for large scale installations. Mixes have also been recommended for small scale (field-trial) installation with the view to refinement and ultimately the development of a more varied palette of seed mixes suitable for large scale installation.

Additional field trials will assess:

- Inter- and intra-specific competition of cool and warm-season grass mixes.

- The addition of wildflowers to both cool and warm-season grass mixes for use in visually sensitive areas of the Landfill.

- The capital cost of establishing a cool-season grass meadow, with subsequent maintenance and management to foster the development of stable native grassland, versus the cost and effectiveness of establishing a native grassland directly.

Landfill conditions will change over time, necessitating responsive refinement of the Cover Vegetation Program. For example, wind impacts and droughty conditions are expected to increase as higher landfill elevations are achieved. Conditions which are unforeseen at the present time will also need to be accommodated as they occur.

Elements of the final cover design grading plans proposed in other sections of this report will affect vegetation. The most significant areas of concern are discussed below:

Exhibit 5 - Current Program Recommendations (1)

TECHNIQUE[2]	SEED MIXTURE[2]							
	Warm-Season Grass Mixes For Planting April through June[3]			Cool-Season Grass Mixes for Planting April through May and September through October[3]				Warm-Season & Cool-Season Mix May Planting Only
	Mix A with Nurse Crop (Sheep Fescue): Big Bluestem Broomsedge Switchgrass Indiangrass Sheep Fescue	Mix B with Native Legume: Indiangrass Switchgrass Partridge Pea	Mix C with Nurse Crop (Sheep Fescue): Little Bluestem Broomsedge Sheep Fescue	Mix A with Legumes: Creeping Red Fescue Hard Fescue Perennial Ryegrass Kentucky Bluegrass Ladino Clover	Mix B with Legumes: Redtop Tall Fescue Perennial Ryegrass Kentucky Bluegrass Rabbitsfoot Clover	Mix C (Pasture): Redtop Orchardgrass Tall Fescue Red Fescue Timothy	Mix D with Native Legumes: Redtop Tall Fescue Partridge Pea	Big Bluestem Broomsedge Switchgrass Indiangrass Orchardgrass Timothy
Imprinting with Hay Mulch	Large[4]	Small[5,*]	Small*	Large (geomembrane hydraulic) Small (soil hydraulic)	Large (geomembrane hydraulic) Small (soil hydraulic)	Small*	Small*	Small*
Two-Step Hydroseed with Wood Fiber Mulch	Small	Small	Small	Large (geomembrane hydraulic) Small (soil hydraulic)	Large (geomembrane hydraulic) Small (soil hydraulic)	Small	Small	Small*
Broadcast and Track with Hay Mulch	Large	Small	Small	Large (geomembrane hydraulic) Small (soil hydraulic)	Large (geomembrane hydraulic) Small (soil hydraulic)	Small	Small	Small*
Drill Seed with Hay Mulch	Large	Small	Small	Large (geomembrane hydraulic) Small (soil hydraulic)	Large (geomembrane hydraulic) Small (soil hydraulic)	Small	Small	Small

(1) This matrix presents representative seeding scenarios only, and is one part of a comprehensive Cover Vegetation Progra.
(3) Unless otherwise noted.
(5) Small = Small-scale application (1 acre or less).

(2) All mixture and technique recommendations are for 3H:1V slopes only. Use on steeper slopes may require additional investigation. Mulching, fertilization, and seeding rates differ slightly for all mixtures.
(4) Large = Large-scale application.
* Priority field trial installation.

- Slope Gradient and Length: Steeper (2.5H:1V) and longer slopes will produce greater volumes and velocities of surface runoff and lower soil moisture reservoir levels. These are factors which will have a direct effect on the success of vegetative establishment and therefore erosion levels and slope stability.

- Soil Hydraulic Barrier Layers: As discussed under section 3.4.2, the soil hydraulic barrier layer will contribute to conditions in the topsoil and subsoil layers, and therefore affect vegetation establishment and maintenance.

These factors must be field-tested to assess their impact on the final cover vegetation. Refinements of seed mixes and techniques will be undertaken to the extent practical to address the concerns about vegetation establishment and maintenance.

3.4.6 WOOD LAND COVER TYPES

3.4.6.1 Overview

Woody vegetation has not historically been planted on landfills for closure; rather local woody species volunteer and naturalize over time if conditions are suitable. The establishment of woody cover types will increase habitat and scenic values exponentially and is fundamental to the idea of a successful reclamation of the Landfill. The restoration of the Landfill to woody vegetation also addresses major mitigation goals of the surrounding population.

Additional benefits are provided to the final cover system through the establishment of woody vegetation communities:

- Slope Stabilization: Many of the native plants recommended for assessment in the field-trials, such as bayberry, High bush, blueberry, and elderberry, have characteristically shallow roots. This type of root system tends to form a dense mat, stabilizing surface soils. Larger woody vegetation, however, can be subject to windthrow. Species and planting techniques which are likely to pose a windthrow problem are not recommended for establishment on the Landfill.

- Erosion Control: Trees and shrubs typically do not provide effective erosion control immediately after installation. Canopy closure, however, will significantly increase rainfall interception; rain-splash effects and surface runoff volumes and velocities will therefore be reduced in the long term. In the short term, woody vegetation communities will be established in combination with grassland to reduce surface erosion.

- Plant Community Stability: Woody plants represent the most mature and stable landscape in the region. The establishment of woody plants on the landfill will minimize long-term maintenance needs at the Landfill.

The root zone of most trees normally remains within the upper 30" of soil. The literature indicates that tree roots are no more likely to penetrate a soil hydraulic barrier layer than are grass roots, especially if shallow-rooted species are used (Perry 1989). Woody vegetation is being tested in a series of Root Penetration Test Plots to determine the feasibility of using shrubs and trees for final cover and to refine the selection of appropriate species. Woody cover types could be direct-planted or managed over time to develop from field cover types, after review and approval by NYCDEC.

Increased labor is generally necessary for the establishment of woody vegetation, especially where larger plant material is installed. Research indicates that woody vegetation should be planted while still small in order that it may best acclimate to landfill conditions. Maintenance requirements also may be greater than for herbaceous species during the establishment phase. However, dense scrublands could provide excellent cover in a few years, and would require almost no maintenance once established.

3.4.6.2 Field Trials and Current Program

The earliest installations of woody plants at the Landfill included a mix of tree and shrub seeds which were hydroseeded on Section 1/9 and broadcast seeded on Section 3/4. Large trees have also been planted in 'islands' in selected areas where 2-4 feet of additional cover soil was placed on Sections 1/9 and 3/4. Several full grown specimens were later dug up with a backhoe, and no roots were observed to have breached the hydraulic barrier layer. Selected native trees and shrubs, adapted to acid soil conditions, have been planted, in sizes ranging from 1 gallon container seedlings to 1 inch caliper trees, as part of a demonstration planting on and adjacent to Section 3/4. Continued monitoring is required to evaluate these installations for their adaptability to the stressful Landfill conditions.

Another woody vegetation installation assessed the use of bioengineering techniques to establish woody vegetation. It is anticipated that such techniques may provide for effective stabilization of open channel stormwater management structures and eliminate the need for rip-rap and

gabions, providing visual mitigation of the artificial appearance of traditional stormwater management features.

Conventional horticultural techniques, which typically limit root growth to containers and favor specimen trees, will probably increase the likelihood of windthrow. Alternative approaches, such as fostering thicket growth and the installation of temporary wind buffers, may reduce these concerns.

Additional installations will focus on developing practical methods of establishing woody vegetation. Replanting this huge area with nursery stock would be very costly. Instead, DOS proposes to introduce small clusters of desirable species, and let ecological processes, based on the principles of reproduction, dispersal, and recruitment, naturally continue the colonization of adjacent areas. Woody plant material will be introduced to the Landfill and monitored for subsequent survival, growth, reproduction, and recruitment over a predetermined period of time (Robinson et al 1990). Comparisons of results from future experimental treatments will permit the design of the most efficient and productive landfill restoration scheme. Future assessments will address protection methods and develop management-techniques for reducing woody vegetation windthrow and windstress. Higher landfill elevations will exacerbate the existing wind velocity problems at the Landfill and associated vegetation stress.

Trees/shrubs proposed for use on the Landfill:

Acer negundo	Box elder
Acer rubrum	Red maple
Amelanchier canadensis	Shadblow
Aronia arbutifolia	Chokeberry
Baccharis halimifolia	Groundsel bush
Betula lenta	Black birch
Betula populifolia	Grey birch
Castanea dentata	American chestnut (disease resistant hybrid spp. being developed by the American Chestnut Foundation)
Celtis occidentalis	Hackberry

Cephalanthus occidentalis	Buttonbush
Comptonia peregrina*	Sweet fern
Cornus amomum	Silky dogwood
Diospyra virginiana	Persimmon
Gaylussacia baccata*	Black huckleberry
Gleditsia triacanthos	Honey locust
Ilex opaca	American holly
Iva frutescens	Marsh elder
Juglans nigra	Walnut
Juniperus virginiana	Red cedar
Lindera benzoin	Spicebush
Liquidambar styraciflua*	Sweet gum
Lyonia ligustrina	Maleberry
Lyonia mariana	Staggerbush
Magnolia virginiana	Sweetbay
Myrica pensylvanica*	Bayberry
Nyssa sylvatica*	Sourgum
Ostrya virginiana	Hop hornbeam
Pinus echinata*	Short-leaf pine
Pinus rigida*	Pitch pine
Populus deltoides	Cottonwood
Prunus maritima	Beach plum
Prunus pensylvanica	Pin cherry
Prunus serotina	Black cherry
Prunus virginiana	Chokecherry
Quercus alba	White oak
Quercus bicolor	Swamp white oak
Quercus borealis	Northern red oak
Quercus ilicifolia*	Scrub oak
Quercus marilandica*	Black jack oak
Quercus palustris	Pin oak
Quercus phellos	Willow oak
Quercus prinus	Chestnut oak
Quercus stellata*	Post oak
Quercus velutina	Black oak
Rhus copallina	Shining sumac

Rhus glabra	Smooth sumac
Robinia pseudo-acacia	Black locust
Salix nigra	Black willow
Sambucus canadensis	Elderberry
Sassafras albidum	Sassafras
Vaccinium angustifolium	Early low-bush blueberry
Vaccinium corymbosum*	High-bush blueberry
Vaccinium vacillans	Late low-bush blueberry
Viburnum prunifolium	Blackhaw

* Especially suited for acid soil conditions.

3.4.7 MONITORING AND MAINTENANCE

3.4.7.1 Overview

The purpose of monitoring and maintenance is to continue to meet the goals for final cover vegetation established by DOS:

- To protect the integrity of the final cover system and cap;
- To sustain low-maintenance native plant communities; and
- To refine techniques for maintaining the health and stability of the cover vegetation.

This program is already well underway and has resulted in a continuing upgrade of installation and management quality based on field-tested projects.

3.4.7.2 Monitoring

The monitoring program is designed to provide practical information to meet DOS's need to assess establishment and on-going vegetation requirements at the Landfill. The Cover Vegetation Program represents an invaluable opportunity to develop innovative landscape management strategies appropriate for use not only at the Landfill, but for future application at similar facilities throughout the region. Several different levels of monitoring are being utilized, as described below, each directed toward a specific goal.

- Baseline Data: Records are now being kept on landscape installation and management actions at the Landfill. A baseline survey which describes soil and vegetation conditions is being compiled for each site. This information will allow continuing evaluation of field trials and is mandatory for the on-going refinement and research necessary for the Cover Vegetation Program.

- Overall Site Review: In addition to the baseline monitoring, a regularly implemented site review is being undertaken by DOS and their consultants. Components of the review include assessment of vegetation health and vigor, effectiveness of vegetation for erosion and sedimentation control, stormwater management impacts on vegetation, extent of invasive exotic vegetation establishment, and success of development of native plant communities. Site observations are recorded, and recommendations and remediation are made as necessary.

- Requirements Monitoring: Monitoring programs will be implemented as required in response to site conditions of concern if they develop. For example, where vegetation dieback is observed, soil pH and landfill gas would be measured immediately. Each program will be tailored to specific management needs and site conditions.

- Specific Monitoring: A wide variety of products and techniques which offer the potential to improve vegetation establishment have been evaluated at the Landfill as part of the Cover Vegetation Program. All installations are initially confined to small field trials until their usefulness is assessed. Some of the products and techniques have been rejected for further use within a single season, and only those field trials which have shown sufficient cost-benefit potential continue to be and used. In addition, several vegetation installation research programs are currently under consideration, including a cooperative venture with Rutgers University to evaluate woody plant succession and root penetration on a four-acre site at the Landfill.

3.4.7.3 Maintenance

The maintenance program at the Landfill is still largely in the planning phase. Current maintenance needs are relatively limited and are implemented during the establishment period. Maintenance needs will increase steadily over time and require significant funding beyond the initial seeding and planting costs. Many of the monitoring activities described above focus on developing cost-effective maintenance techniques, and have enormous potential for cost savings and loss control. The next phase of monitoring and maintenance includes the development of Final Cover Vegetation Management Manuals which will recommend a management program based on observations made during the field trials.

One goal of maintenance at the Landfill is to control the establishment of invasive exotic vegetation. The stressful conditions typical of landfills make them vulnerable to invasion by certain pest species of exotic vegetation. Once established, such vegetation is particularly difficult to control, reducing habitat value as well as stability of native plant communities they invade. A variety of control methods will be assessed in field trials.

3.4.7.4 Funding

The information gathered in the Cover Vegetation Program will allow the analysis of comprehensive long-term costs and funding needs necessary to establish, monitor and maintain enhanced vegetative cover. Factors reviewed will include initial establishment, on-going maintenance, and scenic and habitat values. Maintenance recommendations will be prioritized to permit flexible budgetary programming to ensure that the most critical maintenance tasks are completed.

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Appendix A:

ITEM 16.0 - TOPSOIL FOR CAPPING SYSTEM PILOT PROGRAM

D-16.01 DESCRIPTION

This work shall consist of furnishing, amending if required, placing, and preparing material for seeding as shown on the Drawings and/or as directed by the Engineer.

In general, topsoil will be placed in area of the landfill reserved for the Capping Systems Pilot Program.

D-16.02 SUBMITTALS

D-16.02.1 General: Make submittals in accordance with the provisions and procedures of Item 2.0. Render submittals and receive approval prior to delivery or installation. Submit certified reports at least three (3) weeks prior to delivery of materials to the site.

D-16.02.2 Soil Test Results: Submit soil test results.Soil tests shall be performed by the Soil Testing Laboratory; New Jersey Agricultural Experiment Station; Cook College; Rutgers The State University of New Jersey; P.O. Box 231; New Brunswick, NJ 08903 (201-932-9295). The following information and testing shall be submitted for the Engineers's review and approval:

(a) pH
(b) Specific Conductance
(c) Percent Organic Content
(d) Percent Sand
(e) Percent Silt
(f) Percent Clay
(g) Texture
(h) Fractions
(i) Available Phosphorus
(j) Available Potassium
(k) Available Magnesium
(l) Available Calcium
(m) Seed Content

D-16.02.3 Product Data: Submit product literature, written description or tear sheets giving name of product, manufacturer's name and compliance with specifications for all topsoil amendments.

D-16.03 MATERIAL

D-16.03.1 Topsoil: The topsoil shall be a fertile, friable, natural loam, surface soil of uniform quality with a sandy loam texture and shall not contain subsoil materials. The topsoil shall be free of refuse, hard clods, woody vegetation, stiff clay, construction debris, boulders, stones larger than four (4)

inches in any dimension, materials or chemicals toxic to plants, and any other undesirable material.

All topsoil shall be from off-site sources. On-site topsoil may not be used.

D-16.03.2 Organic Content: The topsoil shall have a minimum organic content of not less than 5.00 percent by volume. The organic content shall be increased by adding humus in the form of partially or completely decomposed leaf mold or approved organic matter at a rate necessary to attain the minimum organic content specified. The organic content of soils shall be determined by the laboratory using the chromic acid titration method as described in the United States Department of Agricutlture's Circular #757.

D-16.03.3 Graduation: The graduation of the topsoil shall be determined by the laboratory using the Bookcase Hydrometer Analysis conforming to the requirements of current ASTM Designation D 422. The graduation of the topsoil shall be within the following ranges:

Material	Particle Diameter	Quantity (percent ovendry wt)
Sand	(2.000mm to 0.050mm)	40% to 65%
Silt	(0.050mm to 0.005mm)	25% to 40%
Clay	(0.005mm and smaller)	10% to 20%

except that when one half of the sand content is larger than 0.500mm, then the maximum sand content shall be 60 percent and the minimum clay content shall be 15 percent. The lower limits of silt and clay shall be flexible to the extent that soils with a minimum combined silt and clay content of 20 percent shall be satisfactory. However, if more than one half of the sand is larger than 0.500mm, then the minimum clay content shall be 15 percent and the minimum combined silt and clay content shall be 25 percent.

D-16.03.4 pH: The topsoil shall have a pH value within a range of 5.5 to 6.5, depending on the seed mix used.

D-16.03.5 Specific Conductance: Soluble salt content (conductivity) for topsoil shall be less than 0.5mmhos/cm for a 1:2 soil:water ratio.

D-16.04 EXECUTION

The contractor shall complete all grading within the area to be covered with topsoil in order to bring the surface of the subsoil to the required grades. Topsoil shall be evenly placed to a minimum thickness of six (6) inches or as directed by the Engineer. The spreading of topsoil shall be performed in such a manner that seeding can proceed without additional soil

preparation or tillage. The grading for both the subsoil and topsoil shall be done with a blade dozer, grading across the slope. The configuration of the final grade to be reviewed and approved by the Engineer prior to beginning the work. Large irregularities in the surface resulting from topsoiling shall be corrected so as to prevent the formation of depressions where water can collect. Topsoil shall not be placed when the subgrade is frozen, excessively wet, extremely dry or in a condition otherwise detrimental to the proposed seeding.

The thickness of the in-place topsoil will be checked after the completion of the work on a pattern and number of test holes established by the Engineer or his representative. The Contractor will be responsible for digging holes in the topsoil to allow for the measurements to be taken. After measurements have been made, the Contractor shall backfill the holes with topsoil. Placement of topsoil shall be performed only when it can be followed within 14 days by planting or seeding operations. After topsoiling and finish grading, no heavy equipment, trucks, etc. shall be permitted to travel on loamed areas. The Contractor shall, through mechanical raking, and hand grading with rakes and shovels, grade all areas around fences, pipes, and other structures in preparation for final seeding.

D-16.04.1 Amending: The Contractor may amend natural topsoil with approved materials and by approved methods to meet the specifications for pH and organic matter content. The Contractor shall submit to the Engineer, for his review and approval the materials and procedures for amendment before any ammendment takes place.

D-16.04.2 Mechanical Raking: The Contractor shall, as part of the topsoil spreading operation, mechanically rake and clean all debris from the topsoil prior to seeding operations. The work shall be performed with equipment commonly used for this purpose which has been approved by the Engineer.

D-16.04.3 Disposal: The Contractor shall dispose of all undesirable materials and debris raked from the topsoil, in accordance with the Specific Provisions.

D-16.04.4 The Contractor is responsible for maintaining erosion protection during and after the placement of the topsoil, as required in Division D-0.21 of the Specific Provisions.

D-16.05 MEASUREMENT

D-16.05.1 Final Cover: Topsoil quantities in areas of final cover shall be measured to the nearest cubic yard in-place material, computed from payment lines shown on the contract drawings, except where revised payment lines have been approved by the Engineer.

The measurement to determine the thickness of the Topsoil will be made perpendicular to the slope and shall be the distance from the surface of the Cover Fill material to the finish grade of the Topsoil. No other measurement will be made to determine the thickness. A deficiency of 1/2 inch will be permitted in the thickness at any particular measurement. However, the arithmetical average of the sum of measurements made over an acre of Topsoiled area will not be less than the thickness specified herein. Measurements will be made by the Engineer or his representative and the Contractor will be responsible for providing the necessary labor and equipment required.

D-16.05.2 Special Project: The quantity of Topsoil for special landscape projects shall be measured by truck volume delivered to the site and determined as water volume of the truck-bed capacity, if the load is full.

D-16.06 PAYMENT

The bid price for work under this section shall constitute full compensation for furnishing , amending, hauling, placing, raking, and preparing Topsoil for final seeding in accordance with this specification or as directed by the Engineer. No additional payment will be made for losses due to settlement, compaction erosion or any other cause. The bid price shall include all labor, equipment, material, and work incidental thereto, and necessary to provide for measurement of the Topsoil during construction.

PAYMENT WILL BE MADE UNDER:

Bid Item No.	Description	Pay Unit
16.1	TOPSOIL BY PAY LINES	Cubic Yard
16.2	TOPSOIL TRUCK VOLUME	

END OF ITEM D-16.0